

MS: 1-1 - Mechanics of Composite Materials

An isotropic damage cohesive model for mixed-mode delamination with large openings and fiber bridging.

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Delamination is among the most frequent failure mechanism in laminated composite materials, often characterized by mixed-mode loading conditions. As underlined in [1, 2], classical cohesive models, formulated under the hypothesis of small openings, are not able to describe the delamination growth either in the presence of extensive fiber-bridging phenomena or when large relative displacements are involved. As shown by a number of DCB tests performed on fiber-reinforced composites, large-scale fiber bridging causes an increment in the fracture energy, typically expressed by an R-curve in which the toughness gradually increases until a steady-state value is reached.

In this work the cohesive model proposed in [3] for the simulation of mixed-mode delamination problems under the assumption of small openings is extended to handle the transition between small and large openings and to account for large-scale bridging or interfacial fibrillation. Consistently with the fact that fiber bridging and fibrillation occur mainly under mode I loading conditions, two different traction-separation laws are considered in pure Mode I and II. A classical bilinear traction-separation law is adopted in pure Mode II. The traction separation law in pure Mode I is, instead, characterized by a trilinear softening branch, consisting of an initial linear branch, followed by a plateau and, then, by a second linear branch up to complete decohesion. It is here assumed that fiber bridging develops when the plateau is reached: this provides a simple activation criterion, also in mixed-mode conditions. Once the fibers activation criterion is fulfilled, the classical interface element is substituted, without introducing any discontinuity in the transmitted tractions and in the remaining energy to be dissipated, with a directional cohesive element, i.e. the cohesive string element developed in [4], able to account for large openings in a consistent way, since the interface tractions and openings are colinear [2].

References

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